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DEVICE FOR ASEPTIC SPLICING OF FLEXIBLE TUBES

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[There are no amendments to this patent.]

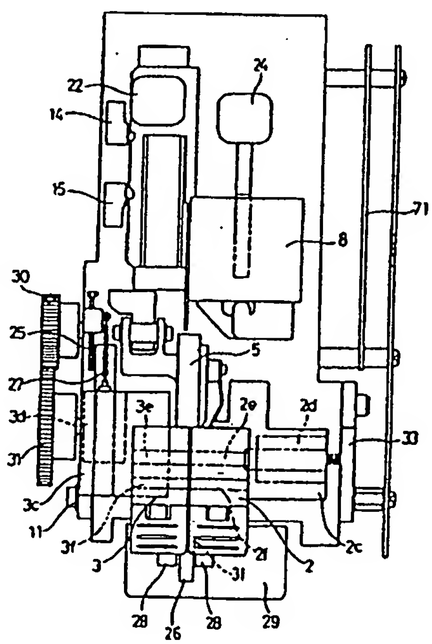
Abstract

Objective

The objective of the present invention is to provide a device for aseptic splicing of flexible tubes wherein two movements, namely, the back-and-forth movement of the first clamp and the side-to-side movement of the second clamp, are executed smoothly and with little deviation in the movement of the clamps; in addition, reliable splicing of the tubes can be realized.

Constitution

A device for aseptic splicing of flexible tubes characterized by the fact that comprises a first clamp and a second clamp for keeping the two flexible tubes to be spliced parallel, cutting means (5) for cutting flexible tubes (48) and (49) between said first clamp (3) and second clamp (2) and the driving means for cutting means 5, a first clamp driving mechanism that moves the first clamp parallel to the second clamp so that the spliced ends of cut flexible tubes (48) and (49) can be arranged opposite each other, and a second clamp driving mechanism that moves the second clamp toward or away from the first clamp.



Claims

1. A device for aseptic splicing of flexible tubes characterized by the fact that it comprises the following parts: a first clamp and a second clamp for keeping at least two flexible tubes parallel; a cutting means arranged between said first and second clamps for cutting said

flexible tubes; a first driving mechanism that drives said first clamp parallel to said second clamp so that the ends for splicing cut by said cutting means are arranged opposite each other; a second clamp driving mechanism that drives said second clamp toward or away from said first clamp; and a cutting means driving means that drives said cutting means up and down between said first clamp and second clamp; in addition, since said first clamp is driven by the first clamp driving mechanism to move parallel to said second clamp so that the are arranged opposite each other, said second clamp driving mechanism can move the second clamp away from said first clamp by pushing said second clamp.

2. A device for aseptic splicing of flexible tubes characterized by the fact that it comprises the following parts: a first clamp and a second clamp for keeping at least two flexible tubes parallel while holding said flexible tubes in a compressed state; a cutting means for cutting said flexible tubes between said first and second clamps; a first driving mechanism that drives said first clamp parallel to said second clamp so that the ends for splicing cut by said cutting means are arranged opposite each other; a second clamp driving mechanism that drives said second clamp toward or away from said first clamp; a cutting means driving means that drives said cutting means up and down between said first clamp and second clamp; where said second clamp driving mechanism has a pressing element for pushing said second clamp toward said first clamp, and is designed so that when first and second clamps hold the two flexible tubes slightly compressed, the pressure of the pressing element is less than the reacting force of the flexible tubes, and when the flexible tubes are held, the second clamp is moved slightly away from the first clamp.

Detailed explanation of the invention

[0001]

Industrial application field

The present invention pertains to a type of device for aseptic splicing of flexible tubes which heats and softens at least two flexible tubes and splices them together.

[0002]

Prior art

When the tubes of the blood collecting bag and blood component bag of a blood transfusion system must be spliced, and when the dialyzing fluid bag and waste fluid bag of a continuous ambulatory peritoneal dialysis (CAPD) must be exchanged, it is necessary that the tubes be spliced aseptically. Japanese Kokoku Patent No. Sho 61[1986]-30582 disclosed a type of device for performing such aseptic splicing of tubes. The device disclosed in said Japanese Kokoku Patent No. Sho 61[1986]-30582 is a tube splicing device in which tubes are heated and

softened for splicing. Figure 19 illustrates an example of the conventional aseptic splicing device. Splicing device (100) shown in Figure 19 has the following means: first clamp (111) and second clamp (110) that hold the two flexible tubes (115) and (116) to be spliced parallel to each other, cutting means (wafer) (114) for cutting the flexible tubes between first clamp (111) and second clamp (110), driving means (113) that moves the first clamp so that the ends of the flexible tubes cut by the cutting means for splicing are arranged opposite each other via the wafer, and driving means (112) that moves cutting means (114) up so that the flexible tubes can be heated and cut and that then moves the wafer down.

[0003]

In this aseptic splicing device, after thin, plate-shaped wafer (114) is heated, it is moved upward between first clamp (111) and second clamp (110) from below to soften and cut flexible tubes (115) and (116) between the first and second clamps; then, first clamp (111) is moved backward (retracted) so that the cut ends of the flexible tubes for splicing are arranged opposite each other. Then, the wafer is moved downward, leaving the ends of the flexible tubes for splicing bonded to each other.

[0004]

Problems to be solved by the invention

In the aforementioned splicing device, after tubes (115) and (116) are cut between first clamp (111) and second clamp (110) by wafer (114), first clamp (left-hand clamp) (111) retracts, and the tubes to be spliced are moved to the position where they are arranged opposite each other via wafer (114). Then, heated wafer (114) is moved downward, and the tubes to be spliced are arranged opposite each other. Then, first clamp (left-hand clamp) (111) is moved to the side of second clamp (right-hand clamp) (110), and the tubes to be spliced are bonded to each other. Thus, second clamp (right-hand clamp) (110) of the aseptic splicing device is always fixed on stationary table (118). First clamp (111) executes two movements: a back-and-forth movement, and a lateral movement toward and away from a second clamp. That is, the same clamp must be moved in two orthogonal directions. This constitution may hinder the correct movement of the clamp, cause deviation in the movement of the clamp and defective splicing of tubes caused by the deviation.

[0005]

The purpose of the present invention is to solve the aforementioned problems of the conventional methods by providing for a device for aseptic splicing of flexible tubes wherein two movements, namely, the back-and-forth movement of the first clamp and the side-to-side

movement of the second clamp are executed smoothly, correctly, and without deviation, so that splicing of the tubes can be carried out reliably.

[0006]

Means to solve the problems

In order to realize the aforementioned objective, the present invention provides a device for aseptic splicing of flexible tubes characterized by the fact that it comprises the following parts: a first clamp and a second clamp for keeping at least two flexible tubes parallel; a cutting means arranged between said first and second clamps for cutting said flexible tubes; a first driving mechanism that drives said first clamp parallel to said second clamp so that the ends for splicing cut by said cutting means are arranged opposite each other; a second clamp driving mechanism that drives said second clamp toward or away from said first clamp; and a cutting means driving means that drives said cutting means up and down between said first clamp and second clamp.

[0007]

Also, in order to realize the aforementioned purpose, the present invention provides a device for aseptic splicing of flexible tubes characterized by the fact that the device comprises the following parts: a first clamp and a second clamp for keeping at least two flexible tubes parallel while holding said flexible tubes in a compressed state; a cutting means for cutting said flexible tubes between said first and second clamps; a first driving mechanism that drives said first clamp parallel to said second clamp so that the ends for splicing cut by said cutting means are arranged opposite each other; a second clamp driving mechanism that drives said second clamp toward or away from said first clamp; a cutting means driving means that drives said cutting means up and down between said first clamp and second clamp; where said second clamp driving mechanism has a pressing element for pushing said second clamp toward said first clamp, and is designed so that when first and second clamps hold the two flexible tubes slightly compressed, the pressure of the pressing element is less than the reacting force of the flexible tubes, and when the flexible tubes are held, the second clamp is moved slightly away from the first clamp.

[0008]

It is preferred that said first clamp driving mechanism have a linear table for the first clamp to move parallel to said second clamp. In addition, it is preferred that said second clamp driving mechanism have a linear table for said second clamp to move toward or away from said first clamp.

[0009]

In the following, the device for aseptic splicing of flexible tubes of the present invention will be explained with reference to figures. This aseptic splicing device (1) for flexible tubes has first clamp (3) and second clamp (2) for keeping at least two flexible tubes (48) and (49) parallel, cutting means (5) for cutting flexible tubes (48) and (49) between first clamp (3) and second clamp (2), a first clamp driving mechanism that drives first clamp (3) parallel to the second clamp (2) so that the ends of flexible tubes (48) and (49) cut by cutting means (5) are arranged opposite each other for splicing, a second clamp (2) driving mechanism that drives second clamp (2) toward or away from first clamp (3), and a cutting means driving means that drives cutting means (5) up and down between first clamp (3) and second clamp (2). Also, for said aseptic splicing device (1), first clamp (3) and second clamp (2) are used to hold two flexible tubes (48) and (49) in a slightly compressed state. Also, second clamp moving mechanism has pressing element (33) that pushes second clamp (2) to the side of first clamp (3). In addition, pressing element (33) is designed so that when the two flexible tubes are held and compressed by first clamp (3) and second clamp (2), the pressure from pressing element (33) is less than the reacting force of the flexible tubes, and when the flexible tubes are held, second clamp (2) is moved slightly away from first clamp (3).

[0010]

Figure 1 is an oblique view illustrating an application example of the device for aseptic splicing of flexible tubes of the present invention. Figure 2 is an oblique view illustrating the state when the aseptic splicing device shown in Figure 1 is placed in a case. Figure 3 is a block diagram illustrating an example of the electrical circuit used in the aseptic splicing device of the present invention. Figure 4 is top view of an application example of the device for aseptic splicing of flexible tubes of the present invention. In this application example, aseptic splicing device (1) can be explained with reference to Figures 1, 2, 3, and 4. The operation of the first clamp, second clamp and the cutting means can be explained with reference to Figure 6. The operation of the first clamp can be explained with reference to Figure 7. The operation of the cutting means may be explained with reference to Figure 8. Also, the operation of the first and second clamps may be explained with reference to Figure 9, which is an oblique view.

[0011]

In the following, the overall structure of aseptic splicing device (1) will be explained. As shown in Figures 1, 2 , 4 and 9, said aseptic splicing device (1) has first clamp (3) and second clamp (2) that hold at least two flexible tubes in the parallel state. There are the following parts: gear (30) rotationally driven by a motor; gear (31) driven to turn by the rotation of gear (30);

shaft (32) rotationally driven by the rotation of gear (31); frame (9) that fixes the two ends of the shaft; play-suppression element (11) for inhibiting play of first clamp (3) at the origin; microswitches (13), (14), and (15); driving arm (18) for driving first clamp (3) to move; cam (19) for moving first clamp (3); cutting means (5), cam (17) for driving cutting means (5) and the second clamp; pressing element (33) for pushing second clamp (2) to the side of the first clamp; restraining member (25) that restrains the retreat of first clamp (3); spring (27) for preventing play in first clamp (3); wafer exchange lever (22); wafer cartridge (8); wafer cartridge exchange lever (24); holding member (28) for used wafer box; guiding member (26) for guiding the used wafer into the box; used wafer box (29); and operation panel (50).

[0012]

Also, as shown in Figure 3, aseptic splicing device (1) in this application example also has the following parts: wafer heating constant-voltage power source (43) which has rectifying power source circuit (41) that converts AC to DC of the prescribed voltage; motor (42) which is also supplied with the power source from said constant-voltage power source (43); controller (40) for controlling motor (42) and wafer heating controller (44); wafer (6) for cutting the flexible tubes by heating and softening; temperature detecting means (7) of wafer (6); and wafer heating controller (44) which controls heating of wafer (6) by controlling the power supplied from constant-voltage power source (43) to wafer (6) on the basis of the signal from temperature detecting means (7). Also, as shown in Figure 5, there is connecting terminal (9) for forming an electrical connection between constant-voltage power source (43) and the wafer. Reset switch (69), which resets the device after the wafer short-circuit operation, is electrically connected to wafer heating control means (44). Also, wafer heating control means (44) is electrically connected to controller (40). Controller (40) has the following parts: microswitch SW1 (13), microswitch SW2 (14), microswitch SW3 (15), microswitch SW4 (72), microswitch SW5 (73), microswitch SW6 (74), power source switch (51) set on input panel (50), start switch (52), and buzzer (45), which is electrically connected to clamp set switch (53) and is turned on upon receiving the signal output from controller (40). Motor (42) is a driving source for driving cutting means (5), first clamp (3) and second clamp (2).

[0013]

Said aseptic splicing device (1) has a first clamp driving mechanism that moves first clamp (3) so that ends (48a) and (49a) of flexible tubes (48) and (49) for splicing cut by cutting means (5) are arranged opposite each other, and [cutting means driving mechanism] that has the function of first moving cutting means (5) toward the tubes (upward) and then away from the tubes (downward) after cutting, and a second clamp driving means that has the function of

driving said second clamp (2) toward or away from first clamp (3). The cutting means driving mechanism moves cutting means (5) upward and perpendicular to the axis of the two tubes, and it moves the cutting means downward after the tubes are cut. After cutting of the tubes, the first clamp driving means has first clamp (3) set in a horizontal state with respect to the axis of the two tubes and moves it in the perpendicular direction (or more specifically, backward), and the second clamp driving mechanism moves second clamp (2) toward the first clamp as it has the second clamp set in the horizontal state with respect to the axis of the two tubes and moves slightly in the parallel direction.

[0014]

First clamp (3) and second clamp (2) will be explained below. Said first clamp (3) and second clamp (2) have the structure shown in Figures 1, 4, 6 and 9. More specifically, as shown in Figure 9, first clamp (3) has base (3b), cover (3a) attached to base (3b) in a rotatable manner, and clamp fixing table (3c) to which base (3b) is fixed. Also, said clamp fixing table (3c) is fixed on the linear table. The linear table is composed of moving table (3c) fixed on the lower surface of clamp fixing table (3c), and rail (3n) arranged on the lower portion of moving table (3c) [sic]. By means of said linear table, first clamp (3) is moved without deviation in the direction perpendicular to the axis of tubes (48) and (49) for splicing, in other words, to make the ends of the flexible tubes that have been cut for splicing face each other. Consequently, in aseptic splicing device (1) of this application example, the first clamp driving mechanism is composed of said linear table, a motor, gear (30), gear (31), shaft (32), driving arm (18), and cam (19). In this splicing device (1), as shown in Figures 1 and 4, spring (27) is arranged to connect the rear side of first clamp fixing table (3c) and the frame of splicing device (1), and first clamp (3) is normally pulled backward under tension so that first clamp (3) (or, more correctly, first clamp fixing table (3c)) has little play. Also, as shown in Figures 1 and 4, at the tube mounting position of first clamp (3) (in other words, in its most forward position), play-suppression element (11) for inhibiting the play of first clamp (2) is fixed to the side surface of frame (9). Consequently, at the tube installation position, first clamp (3) is pulled under tension by spring (27). Consequently, there is no play on the rear side. Also, by means of a play-suppression element on the front, there is no way to move forward. Consequently, first clamp (3) has a structure that enables no play at the tube installing position. Also, as shown in Figures 1 and 4, on splicing device (1), restraining member (25) that restrains the maximum movement position on the rear side of first clamp (3) (or more correctly, first clamp fixing table (3c)) is set.

[0015]

As shown in Figures 4, 6 and 9, second clamp (2) has base (2b), cover (2a) mounted on base (2b) in a rotatable manner, and clamp fixing table (2c) on which base (2b) is fixed. Said clamp fixing table (2c) is fixed on a linear table. The linear table is composed of moving table (2c) fixed to the lower surface of clamp fixing table (2c) and rail (2n) arranged on the lower portion of moving table (2c). By means of this linear table, second clamp (2) can be moved without deviation in the direction parallel to the axis of tubes (48) and (49); in other words, second clamp (2) can only be moved toward or away from first clamp (3).

[0016]

As shown in Figures 4 and 6, pressing element (33) is arranged between the frame of splicing device (1) and clamp fixing table (2c), and it constantly pushes second clamp (2) (or more correctly, second clamp fixing table (2c)) toward the first clamp. A spring may preferably be used as the pressing element. Said pressing element (33) is designed so that when first clamp (3) and second clamp (2) hold and compress two flexible tubes (48) and (49), the pressure of pressing element (33) is less than the reacting force of the flexible tubes, and when the flexible tubes are held, second clamp (2) is moved slightly away from first clamp (3). Consequently, for aseptic splicing device (1) of this application example, said second clamp driving mechanism is composed of said linear table, motor, gear (30), gear (31), shaft (32), cam (17), and pressing element (33).

[0017]

As shown in Figure 9, first clamp (3) and second clamp (2) are designed so that they hold the tubes as the tubes are obliquely pushed and compressed. Clamps (3) and (2) have covers (3a) and (2a) which are mounted in a rotatable manner on bases (3b) and (2b), respectively. On bases (3b) and (2b), there are two slots (3f), (3e) and (2f), (2e) arranged parallel to each other for carrying the two tubes, respectively. On the end surfaces of bases (3b) and (2b) of the portions of slots (3f), (3e) and slots (2f), (2e) facing each other, sawtooth-shaped closing elements (3h) and (2h) are respectively arranged. Sawtooth-shaped closing elements (3g) and (2g) corresponding to closing elements (3h) and (2h) of said bases (3b) and (2b) are respectively arranged on covers (3a) and (2a). The interior surfaces of covers (3a) and (2a) are flat. Also, covers (3a) and (2a) have rotating cams for closing covers (3a) and (2a), which engage with the rollers of bases (3b) and (2b). For the two tubes, when covers (3a) and (2a) are closed, the portion between closing element (3h) of base (3b) and closing element (3g) of cover (3a), and the portion between closing element (2h) of base (2b) and closing element (2g) of cover (2a) are obliquely compressed, and the closed state is maintained. Also, first clamp (3) has projecting portion (3i) that protrudes

toward the second clamp, while second clamp (2) has recessed portion (2i) for accommodating said projecting portion (3i). Consequently, second clamp (2) is designed so that it cannot be closed if first clamp (1) is not closed.

[0018]

In addition, for closing elements (2g) and (2h) of second clamp (2), the tip of closing element (2hf) as shown in Figure 18 and the tip of closing element (2g) facing said closing element (2hf) and not shown in the figure protrude toward the first clamp more than the tip of closing element (2he). Consequently, distance X_1 between wafer (6) and closing element (2hf) is less than distance X_3 between wafer (6) and closing element (2he). Usually, in said aseptic splicing device (1), tube (49) which is filled with fluid and is in use, is mounted on front slots (2f) and (3f), while unused tube (48) is mounted on rear slots (2e) and (3e). Consequently, distance X_1 between wafer (6) and closing element (2hf) on the side where the tube in use is mounted is smaller, and the length of the portion of tube (49) not held and positioned between clamps (3) and (2) becomes shorter. Consequently, it is possible to reduce the amount of the fluid in tube (49) positioned between the clamps. Also, by having a greater distance X_3 between wafer (6) and closing element (2he) on the side where the unused tube is mounted, it is possible to increase the length of the unused tube to be softened during softening and cutting by the wafer, so as to ensure a more reliable joint with the left-side portion of tube (49) that has been cut and in use.

[0019]

As shown in Figure 1, aseptic splicing device (1) contains gear (30) which is rotated by a motor, and gear (31) rotates as a result of the rotation of said gear (30). As shown in Figure 6, two cams (19) and (17) are fixed on shaft (32) of gear (31). Cams (19) and (17) rotate together with rotation of gear (31). On the right-side surface of cam (19) is formed cam groove (19a) for driving the first clamp and having the shape shown in Figure 7. Also, there is arm (18) for moving the first clamp and having follower (18a) that slides in cam groove (19a) of cam (19) at its center. Also, the lower end of arm (18) is supported in a rotatable manner on frame (9) by supporting point (18b). The upper end of arm (18) is supported in a rotatable manner by supporting point (18c) arranged on clamp fixing table (3c) of the first clamp (3). Consequently, as shown in Figure 7, when cam (19) rotates, first clamp (3) moves along rail (3n) of the linear table and following the profile of cam groove (19a), as indicated by the arrow to the rear side in the orthogonal direction while it is in the horizontal state with respect to the axis of the two tubes.

[0020]

As shown in Figure 5, cutting means (5) has wafer holding unit (5a) that can hold the wafer in a replaceable manner, arm unit (5c) arranged below wafer holding unit (5a), follower (5b) set on the end portion of arm unit (5c), hinge unit (5d), and mounting unit (5e) for mounting on frame (9). By means of hinge portion (5d), it can rotate with respect to frame (9). As shown in Figure 5, on the right side surface of cutting means (5), electrical connecting terminal (9) for heating the wafer and temperature detecting means (7) for detecting the wafer temperature are fixed. It is preferred that a thermocouple or a thermistor be used as said temperature detecting means (7). More preferably, a sheet-shaped thermocouple or thermistor is used. In particular, the sheet-shaped thermocouple is preferred. Wafer (6) preferably is composed of a metal sheet bent face to face, an insulating layer formed on the inner surface of the metal sheet, a resistor formed in the insulating layer without contact with said metal sheet, and terminals arranged on the two ends of the resistor for power feeding.

[0021]

As shown in Figures 5 and 8, cam (17) has cam groove (17a) for driving the cutting means formed on its left side surface. Follower (5b) of cutting means (5) is positioned in cam groove (17a) of cam (17), and it slides in cam groove (17a) along the profile of the cam groove. Consequently, as shown in Figure 8, as cam (17) is rotated, cutting means (5) moves vertically following the profile of cam groove (17a), that is, it moves vertically in the direction orthogonal and perpendicular [sic] to the axis of the two tubes. In addition, as shown in Figure 6, cam (17) has cam groove (17c) for driving second clamp (2) in the central portion. Cam groove (17c) has left side surface (17f) and right side surface (17e). By means of left side surface (17f) and right side surface (17e), the position of the second clamp is controlled. Said clamp fixing table (2c) has a projecting portion that extends downward, and follower (20) is set on its tip. Said follower (20) slides in cam groove (17c) for driving second clamp (2). Then, as shown in Figure 6, there is a certain gap formed between follower (20) and cam groove (17c). Since second clamp-fixing table (2c) is constantly pushed by spring member (33), in the normal state, follower (20) is in contact with left side surface (17f) of cam groove (17c), and there is a certain gap between follower (20) and right side surface (17e) of cam groove (17c). However, the two tubes are held by first clamp (3) and second clamp (2) as explained above; when the two clamps (3) and (2) are closed, they hold the two tubes in a compressed state. Consequently, the tubes exert a reaction force. Since the force from spring member (33) is smaller than the reaction force caused by said closure of the tubes, as shown in Figure 6, in the state with clamps (3) and (2) holding the tubes, follower (20) is in contact with right ride surface (17e) of cam groove (17c), and there is a certain gap between follower (20) and left side surface (17f) of cam groove (17c). However,

since said tubes are cut by said cutting means (5), the reaction force caused by closure of the tubes disappears so that it returns to the normal state, follower (20) comes in contact with left side surface (17f) of cam groove (17c), and there is a certain gap between follower (20) and right side surface (17e) of cam groove (17c). In this way, due to the function of spring member (33) and the reaction force of the tubes, the sliding surface of the cam groove in contact with follower (20) varies with time.

[0022]

As shown in Figure 6, recessed portion (17d) is formed on left side surface (17f). When follower (20) passes through this recessed portion (17d), the tubes have been cut by the cutting means. Consequently, follower (20) slides along left side surface (17f) of cam groove (17). As a result, follower (20) enters the portion of recessed portion (17). Consequently, second clamp (2) moves in the direction toward first clamp (3) by a distance corresponding to the depth of recessed portion (17d). In this way, splicing of the tubes can be performed reliably. Recessed portion (17g) is formed on right side surface (17e) of cam groove (17c). This recessed portion (17g) is for cleaning the inner surface of clamps (3) and (2). By setting recessed portion (17g), by pushing second clamp (2) to the side of spring member (33), second clamp (2) is moved away from first clamp (3) until follower (20) comes in contact with recessed portion (17g). In this way, a gap is formed between first clamp (3) and second clamp (2). The interior of the gap formed can be cleaned with a cotton swab impregnated with a solvent, such as alcohol, that can dissolve the material that forms the tubes that have been cut. As shown in Figure 6, said recessed portion (17g) is set at a position nearly facing recessed portion (17d) of left side surface (17f) (the portion for second clamp (2) to perform lateral shifting). When follower (20), set on the projecting portion protruding below second clamp fixing table (2c), enters dip portion (17d) after the tubes are cut, the target tubes are spliced together. In this state, the second clamp is stopped. The first clamp is also stopped, and first clamp (3) is at a position deviated from the second clamp. More specifically, as shown in Figure 1, first clamp (3) retreats from second clamp (2), and first clamp (3) is at a position deviated from the second clamp. Consequently, in this state, the inner surface of the tip portion of second clamp (2) is slightly exposed, and the inner surface of the rear end portion of the first clamp is also slightly exposed. Consequently, cleaning becomes easy for the exposed inner surface of second clamp (2) and first clamp (3).

[0023]

In the following, the function of aseptic splicing device (1) of the present invention will be explained with reference to figures. Figure 10 is a timing chart illustrating the operation of the first clamp and the second clamp. Figures 11, 12 and 13 are flow charts illustrating the function

of the aseptic splicing device. Figures 14, 15, 16 and 17 illustrate the function of the aseptic splicing device. Figure 18 illustrates the movement of the first and second clamps of aseptic splicing device (1) and the holding state of the tubes. For this splicing device (1), at the end of the splicing operation, first clamp (3) is at a position deviated from second clamp (2), that is, at the stop position of the timing chart shown in Figure 10. For the timing chart shown in Figure 10, the angle represented by the ordinate is 0° at the origin (the state in which the first clamp and the second clamp meet), and the figure illustrates the movement of the cutting means (wafer), first clamp (3) and second clamp (2) at the rotating angle of shaft (32) of gear (31), that is, the rotating angle of cam (17) and cam (19).

[0024]

First of all, as shown in the flow chart of Figure 11, power source switch (51) set on panel (50) shown in Figure 3 is pushed. In this way, by means of the CPU that forms controller (40) shown in Figure 3, splicing device (1) determines whether there is no abnormality (more specifically, whether there is no detachment of the internal connector, broken wire of the thermocouple, or incorrect internal voltage from the power source). If an abnormality is found, the buzzer is turned on. Then, clamp reset switch (53) arranged on panel (50) shown in Figure 3 is pushed. Then, by means of the CPU, it is determined whether the first and second clamps are opened, whether the first and second clamps are at the origin, and whether the wafer exchange lever is at the origin. As explained above, for the clamps used in aseptic splicing device (1) of this application example, said first clamp (3) has projecting portion (3i) protruding toward the second clamp, and second clamp (2) has recessed portion (2i) for accommodating said projecting portion (3i). Thus, if first clamp (1) [sic; (3)]is not closed, second clamp (2) cannot be closed. Consequently, the state of opening of the first and second clamps is detected by contact lever (16) and microswitch (13) that is turned on/off by said lever (16) when the second clamp is closed. More specifically, when the second clamp is in the released state, microswitch (13) turns off, and when second clamp (2) is closed, it makes contact with lever (16), lever (16) moves, and microswitch (13) turns on. The on/off signal of said microswitch (13) is input to controller (40). The state when the first and second clamps are not at the origin is judged as the grooves formed on the circumference of the cams are detected by microswitches SW5 (73) and SW6 (74). The state when wafer exchange lever (22) is at the origin is detected by microswitch (14). When lever (22) is at the origin, microswitch (14) is on. When it is not at the origin, the microswitch is off. The on/off signal of said microswitch (14) is input to controller (40).

[0025]

As shown in Figure 11, when all of the aforementioned four judgments are yes, the motor is turned on, and the first and second clamps are reset to the origin. On the other hand, when one of said four judgments is no, the buzzer is turned on, the abnormality-indicating lamp is lit, manual release is carried out by pushing the reset switch so as to turn off the abnormality-indicating lamp. After the first and second clamps reach the origin, two flexible tubes (48) and (49) are installed on the first and second clamps. In this state, as shown in Figure 9, both first and second clamps (3) and (2) are opened, and slots (3e) and (2e) as well as (3f) and (2f) formed on them face each other. Then, tube (49) in use is installed on front slots (3f) and (2f), while connected unused tube (48) is installed on rear slots (3e) and (2e).

[0026]

After said first clamp and second clamp (3) [sic; first clamp (3) and second clamp (2)] are closed, wafer exchange lever (22) is pushed to the side of the clamp, and the wafer is exchanged. By pushing wafer exchange lever (22) to the side of the clamp, the new wafer is taken out from the interior of wafer cartridge (8), and the new wafer is used to push the standby wafer installed on cutting means (5), and the standby wafer pushes the used wafer installed on cutting means (5), so that while the standby wafer is installed at the use position, the used wafer is accommodated in used wafer box (29). Then, as start switch (52) on panel (50) is pushed, it goes to step ② in the flow chart shown in Figure 12. By means of the CPU that forms controller (40) shown in Figure 3, whether the first and second clamps are closed, whether the wafer has been exchanged, whether the first and second clamps are at the origin, whether the wafer exchange lever is at the origin, and whether the first and second clamps are closed are detected by lever (16) that comes in contact when the second clamp is closed, and microswitch (13) which is turned on/off by said lever (16). More specifically, when second clamp (2) is in the released state, microswitch (13) turns off; when second clamp (2) is closed, it makes contact with lever (16), lever (16) moves, and microswitch (13) turns on. The on/off signal of microswitch (13) is input to controller (40). Whether or not the wafer has been exchanged is detected as follows: as wafer exchange lever (22) is pushed toward the clamps, and the wafer exchange operation is carried out, exchange lever (22) once turns microswitch (15) on, so that whether exchange has been made is detected by the on signal from microswitch (15). The on/off signal of microswitch (15) is input to controller (40). Whether the first and second clamps are at the origin is detected by microswitches (5) and (6) as explained above.

[0027]

As shown in Figure 12, when any one of the aforementioned four judgments is no, the buzzer is turned on, and process control returns to ③ in Figure 11. On the other hand, when all of the aforementioned four judgments are yes, operation-indicating lamp (47) is turned on, and heating of the wafer is started. After start of heating of the wafer, it is determined whether the wafer current is higher than a prescribed level. This judgment is made to determine whether short-circuit takes place for the wafer. If it is found that the wafer current is not below a preset level (that is, when the voltage applied to the shunt resistor is above a prescribed level), after waiting for 0.3 sec, it is again determined whether the wafer current is within the prescribed range. When use of the wafer has completed, due to the thermal history of the resistor, the resistance value decreases. Consequently, the wafer current is measured and compared with a preset wafer current to determine whether it is within the preset range (allowable range). In this way, whether use of the wafer has been completed is judged electrically. If the aforementioned wafer current is higher than the preset level (when short-circuit takes place for the wafer) and when the aforementioned wafer current is not within the preset range (when use of the wafer has been completed), the buzzer is turned on, heating of the wafer is stopped, the wafer abnormality-indicating lamp is turned on. After the reset switch is pushed, process control goes to step ⑤ in the flow chart shown in Figure 11. Then, the wafer current is evaluated. If the wafer current is found within the preset range (the allowable range), heating of the wafer is continued. Heating of wafer (6) is carried out under control of constant-voltage power source (43) by means of the pulse-width modulation signal calculated on the basis of the output of detection of temperature by thermocouple (7) as the means for detecting the temperature of the wafer. In order to prevent excessive heating of the wafer, it is determined whether the heating time of the wafer is within a prescribed time. Also, it is determined whether the wafer current is below a prescribed level. If it is below the prescribed level, that is, if the wafer is accidentally short-circuited, the buzzer is turned on immediately, and heating of the wafer is turned off. Process control then goes to step ⑤ in the flow chart shown in Figure 11. Then, as the temperature of the wafer reaches the preset temperature, it goes to step ④ in the flow chart shown in Figure 13, and the motor is turned on. In this way, gears (30) and (31) and cams (19) and (17) are rotated, the cutting means (wafer) is raised so that cutting of tubes, retreat of the first clamp, lowering of the cutting means (wafer), and lateral shifting of the second clamp toward the first clamp are carried out.

[0028]

Then, as shown in the flow chart as Figure 13, lifting of the wafer, cutting of tubes, retreat of the first clamp, and lowering of the wafer are performed in order. More specifically,

first of all, since cam (17) is rotated in the direction indicated by the arrow, follower (5b) of cutting means (5) slides in cam groove (17a). The state changes from the initial state, in which origin O of the cam groove is in contact with follower (5b) as shown in Figures 8 and 10, to the state in which point A of cam groove (17a) is in contact with follower (5b) as shown in Figures 8 and 10. Then, as shown in Figures 8 and 10, during the process when the state changes from that in which point A of cam groove (17a) is in contact with follower (5b) to that in which point B of cam groove (17a) is in contact with follower (5b), cutting means (5) is raised gently as shown in Figure 10, and during this lifting process, the two flexible tubes are cut. Explanation can be made with reference to Figures 14 and 15. Two tubes (48) and (49) are held by first clamp (3) and second clamp (2), tube portions (48a) and (49a) are formed between first clamp (3) and second clamp (2), and wafer (6) as the cutting means is positioned below them. As explained above, as cam (17) is rotated, cutting means (5) (wafer (6)) is raised, so that, as shown in Figure 15, tube portions (48a) and (49a) of the two tubes positioned between first clamp (3) and second clamp (2) are softened and cut.

[0029]

Then, as shown in Figure 8, during the process when the state changes from that in which point B of cam groove (17a) is in contact with follower (5b) to that in which point C of cam groove (17a) is in contact with follower (5b), as shown in Figures 8 and 10, the raised state of cutting means (5) is maintained, and the cut ends of tubes (48a) and (49a) are well softened. Then, during the process when the state changes from that in which point C of cam groove (17a) is in contact with follower (5b) as shown in Figures 8 and 10 to that in which point E of cam groove (17a) is in contact with follower (5b), as shown in Figures 8 and 10, cutting means (5) is gently lowered. Also, as shown in Figure 7, as cam (19) is rotated in the direction indicated by the arrow, follower (18a) formed on arm (18) for moving the first clamp slides in cam groove (19a). The state in which origin O of the cam groove is in contact with follower (18a) as shown in Figures 7 and 10 changes to the state in which point F of cam groove (19a) is in contact with follower (18a) as shown in Figures 7 and 10. As shown by the timing chart of Figure 10, follower (18a) arrives at point F of cam groove (19a) slightly before follower (5b) of cutting means (5) reaches point B of cam groove (17a). As shown in Figures 7 and 10, during the process when the state changes from that in which point F of cam groove (19a) is in contact with follower (18a) to that in which point G of cam groove (19a) is in contact with follower (18a), as shown in Figure 10, first clamp (3) is retreated slowly to the state shown in Figure 16, and spliced tube portions (49a) and (48a) are arranged opposite each other via wafer (6). As shown by the timing chart of Figure 10, this state is maintained during the period when the state changes from that in which point G of cam groove (19a) is in contact with follower (18a) to that in which

point C of cam groove (17a) is in contact with follower (5b). Also, the position of the second clamp as shown in Figure 16 is maintained during the period when the state changes from that in which point G is in contact with follower (18a) to that in which point H of cam groove (19a) is in contact with follower (18a). Also, as explained above, during the process when the state changes from that in which point C of cam groove (17a) is in contact with follower (5b), as shown in Figures 8 and 10, to that in which point E of cam groove (17a) is in contact with follower (5b), as shown in Figures 8 and 10, cutting means (5) is gently lowered, and tube portions (48a) and (49a) for splicing are in contact with each other.

[0030]

Then, almost at the same time when the descent of cutting means (5) comes to an end, that is, when point E of cam groove (17a) reaches the state in which it is in contact with follower (5b), as shown in Figures 6 and 10, second clamp (2) shifts laterally toward the first clamp. More specifically, as shown in Figures 6 and 10, during the process when the state changes from that in which point M on the left side surface (17d) of cam groove (17c) is in contact with follower (20) for driving second clamp (2) to that in which point L on the left side surface is in contact with follower (20), second clamp (2) is slowly moved toward first clamp (3). During the process of change of the state from that in which point LK of recessed portion (17d) of cam groove (17c) is in contact with follower (20) to that in which point K of recessed portion (17d) is in contact with follower (20), the lateral shifting state is maintained. Due to the lateral shifting, tube portions (48a) and (49a) are in reliable, close contact with each other. Consequently, splicing of the two tubes can be carried out reliably. Then, during the process when the state changes from that in which point K of recessed portion (17d) of cam groove (17c) is in contact with follower (20) to that in which point J on left side surface (17f) is in contact with follower (20), second clamp (2) is moved slowly away from first clamp (3), and, in this state, the motor is turned off.

[0031]

Consequently, as shown in Figure 17, when stopped, the positions of first clamp (3) and second clamp (2) become the same deviated positions as shown in Figure 16. Then, as shown by the flow chart in Figure 13, the wafer temperature is detected by a thermocouple. If the wafer temperature is below the preset level, the operation lamp is turned off, and the buzzer is turned on. Then, as shown in Figure 17, first clamp (2) and second clamp (3) are opened, and the tubes are removed. In this way, the splicing operation of the tubes comes to an end.

[0032]

In the conventional aseptic splicing device, the first clamp and the second clamp are designed so that the tubes are compressed as they are held. As shown in Figure 18 (A-1), the front portion of first clamp (3) is separated from wafer (6) by distance X_2, and the second clamp is separated from wafer (6) by distance X_1. When first second clamp (3) and second clamp (2) are completely fixed, as shown in Figure 18 (A-2), the portion of the two pressed and compressed tubes between the first and second clamps expands, and this will later cause trouble in splicing of the tubes. Consequently, as shown in Figure 18 (A-2), in the conventional splicing device, as second clamp (2) (right clamp) is fixed, when first clamp (3) (left clamp) holds and compresses the two tubes, it is pushed by the reaction force of the tubes, and the first clamp moves slightly away from the second clamp. In this way, first clamp (3) is separated from wafer (6) by a distance of ($X_2 + \Delta x$). Also, a spring is arranged so that after the reaction force disappears, that is, after the tubes are cut by the wafer, as shown in Figure 18 (A-3), the spring pushes the first clamp toward the second clamp as it extends toward the second clamp.

[0033]

Also, in the splicing device of this type, used tube (49) filled with the fluid is loaded on the front slits of the clamps, while the unused tube (48) for splicing is loaded on the rear slits of the clamps to perform splicing of the two tubes. However, as shown in Figure 13 (A-2), for the conventional splicing device, first clamp (3) holds tubes (48) and (49) and moves to the left side. Consequently, wafer (6) cuts the right side of the portion that is held between first clamp (3) and first [sic; second] clamp (2) and expands a little. Usually, fluid is present inside the portion of the tube which is in use and is held between first clamp (3) and second clamp (2), and which expands a little. When its right side is cut, as shown in Figure 13 (A-3), the fluid is left on the surface of the wafer, and it may cause defective splicing of the tubes. However, in aseptic splicing device (1) of the present invention, the end surface of the tube for splicing on the side of the first clamp is kept clean, so that splicing of the tubes can be carried out reliably.

[0034]

More specifically, in the conventional aseptic splicing device, as shown in Figure 18 (A-2), when the tubes are held, the reaction force drives the first clamp away from the second clamp. As the tubes are softened and cut by the heated wafer, as shown in Figure 18 (A-3), the first clamp again moves toward the second clamp. Consequently, in the step of (A-3) in Figure 18, part of the softened material and contents of the tube portion with a length corresponding to the distance of movement (Δx) of the first clamp toward the second clamp melts and adheres to the wafer surface (the surface of the wafer on the side of the second clamp). Then, as shown in

Figure 18 (A-4), the first clamp is moved to the rear side for splicing of the tubes. In this case, since the melted resin and contents attached to the surface of the wafer are entrained, it is difficult to realize a clean end surface for the end surface of the tube for splicing on the side of the first clamp. As a result, defective splicing of tubes may take place for the splicing portion of the tubes formed after the wafer is moved downward and the spliced tubes are bonded to each other.

[0035]

According to the present invention, aseptic splicing device (1) is designed so that the first clamp and the second clamp hold and compress the two tubes in the same way as in the conventional aseptic splicing device. As shown in Figure 18 (B-1), the front portion of first clamp (3) is separated from wafer (6) by distance X_1. Also, second clamp (2) is separated from wafer (6) by distance X_2. As shown in (B-2) on the left side in Figure 18, the structure is such that when first clamp (3) (the left clamp) holds and compress the two tubes, the reaction force of the tubes is suppressed and the second clamp is moved slightly away from the first clamp. In this way, second clamp (2) is separated from wafer (6) by distance ($X_1 + \Delta x$). Also, after disappearance of the reacting force of the tubes, that is, after cutting of the tubes by the wafer, as shown in Figure 18 (B-3), second clamp (2) is pushed by spring member (23) and moves toward first clamp (3) again.

[0036]

Consequently, in aseptic splicing device (1) of the present invention, as shown in Figure 13 (B-2), clamps (3) and (2) hold tubes (48) and (49), and the second clamp is moved to the right side. Consequently, wafer (6) is held between first clamp (3) and first [sic, second] clamp (2), and the left side of the portion that has slightly expanded is cut. Tube (49) in use is held between first clamp (3) and first [sic; second] clamp (2), and there usually exists fluid inside the portion that has expanded slightly. However, since the left side is cut, the fluid is not left on the surface of the wafer. Consequently, it is possible to prevent defective splicing of tubes caused by the fluid left on the surface of the wafer.

[0037]

In addition, with respect to second clamp (2) of splicing device (1) of the present invention, as the tubes are softened and cut by the heated wafer, as shown in Figure 18 (B-3), second clamp (2) moves again toward the first clamp. Consequently, in the step of (B-3) shown in Figure 18, part of the softened tube material with a length corresponding to the distance of movement (Δx) of the second clamp toward the first clamp melts and adheres to the surface of

the wafer (the surface of the wafer facing the second clamp). Then, as shown in Figure 18 (B-4), the first clamp moves to the rear side for splicing of the tubes. In this case, since the amount of the melted resin and contents attached to the surface of the wafer on the side of the first clamp is less than that on the surface of the wafer on the side of the second clamp, there is little chance for the melted resin and contents attached to the surface of the wafer to be entrained, and the end surface of the tube for splicing on the side of the first clamp becomes clean. Also, since there is no movement of the tube with respect to the surface of the wafer on the side of the second clamp on which much melted resin is adhered, the end surface of the tube for splicing on the side of the second clamp also becomes clean. Consequently, there is little risk that the splice formed will be defective.

[0038]

Effect of the invention

The present invention provides a device for aseptic splicing of flexible tubes characterized by the fact that it comprises the following parts: a first clamp and a second clamp for keeping at least two flexible tubes parallel; a cutting means arranged between said first and second clamps for cutting said flexible tubes; a first driving mechanism that drives said first clamp parallel to said second clamp so that the ends for splicing cut by said cutting means are arranged opposite each other; a second clamp driving mechanism that drives said second clamp toward or away from said first clamp; and a cutting means driving means that drives said cutting means up and down between said first clamp and second clamp; in addition, since said first clamp is driven by the first clamp driving mechanism to move parallel to said second clamp so that the ends for splicing cut by said cutting means are arranged opposite each other, said second clamp driving mechanism can move the second clamp away from said first clamp by pushing said second clamp. Consequently, the first clamp only moves back and forth, and the second clamp only moves toward or away from the first clamp. It is then possible to ensure that the clamps will move correctly and without deviation, so that splicing of the tubes can be performed reliably.

[0039]

Also, the present invention provides a device for aseptic splicing of flexible tubes characterized by the fact that it comprises the following parts: a first clamp and a second clamp for keeping at least two flexible tubes parallel while holding said flexible tubes in a compressed state; a cutting means for cutting said flexible tubes between said first and second clamps; a first driving mechanism that drives said first clamp parallel to said second clamp so that the ends for splicing cut by said cutting means are arranged opposite each other; a second clamp driving mechanism that drives said second clamp toward or away from said first clamp; a cutting means driving

means that drives said cutting means up and down between said first clamp and second clamp; when said second clamp driving mechanism has a pressing element for pushing said second clamp toward said first clamp, and is designed so that when first and second clamps hold the two flexible tubes slightly compressed, the pressure of the pressing element is less than the reacting force of the flexible tubes, and when the flexible tubes are held, the second clamp is moved slightly away from the first clamp. Consequently, as explained above, the first clamp only moves back and forth, and the second clamp only moves toward or away from the first clamp. As a result, it is possible to ensure that the clamps will move correctly and with reduced deviation, so that splicing of the tubes can be performed reliably. In addition, in the splicing device of the present invention, the amount of melted resin and contents attached to the surface of the wafer which is moved backward for splicing of the tubes (the surface of the wafer on the side of the first clamp) is less than that attached to the wafer surface on the opposite side (the surface of the wafer on the side of the second clamp). Consequently, there is little risk that melted resin and contents attached to the surface of the wafer will be entrained. It is thus possible to ensure a clean end surface of the tube for splicing on the side of the first clamp, and there is no defective bonding of the tubes once they are spliced together.

Brief description of the figures

Figure 1 is an oblique view illustrating an application example of the device for aseptic splicing of flexible tubes of the present invention.

Figure 2 is an oblique view illustrating the state in which the aseptic splicing device shown in Figure 1 is placed in a case.

Figure 3 is a block diagram illustrating an example of the electric circuit used in the aseptic splicing device of the present invention.

Figure 4 is an upper view of an application example of the aseptic splicing device of the present invention.

Figure 5 is a left side view of an example of the cutting means used in the aseptic splicing device of the present invention.

Figure 6 is a diagram illustrating the operation of the first clamp, the second clamp, and the cutting means.

Figure 7 is a diagram illustrating the operation of the first clamp.

Figure 8 is a diagram illustrating the operation of the cutting means.

Figure 9 is an oblique view illustrating an example of the first and second clamps used in the aseptic splicing device of the present invention.

Figure 10 is a timing chart illustrating the operation timing of the first clamp, the second clamp, and the cutting means.

Figure 11 is a flow chart illustrating the function of the aseptic splicing device in the present invention.

Figure 12 is a flow chart illustrating the function of the aseptic splicing device in the present invention.

Figure 13 is a flow chart illustrating the function of the aseptic splicing device in the present invention.

Figure 14 is a flow chart illustrating the function of the aseptic splicing device in the present invention.

Figure 15 is a flow chart illustrating the function of the aseptic splicing device in the present invention.

Figure 16 is a flow chart illustrating the function of the aseptic splicing device in the present invention.

Figure 17 is a flow chart illustrating the function of the aseptic splicing device in the present invention.

Figure 18 is a diagram illustrating the movement of the first and second clamps of the aseptic splicing device, and the holding state of the tubes.

Figure 19 is an oblique view of a conventional device for aseptic splicing of flexible tubes.

Brief explanation of reference numbers

1	Aseptic splicing device
2	Second clamp
3	First clamp
3d	Moving table of the linear table
3h	Rail of the linear table
33	Pressing method
5	Cutting means
6	Wafer
7	Wafer temperature detection means
9	Electrical connecting terminal for heating of wafer
13	Microswitch 1
14	Microswitch 2
15	Microswitch 3
48	Tube
49	Tube
40	Controller

41 Rectifying power source circuit
42 Motor
43 Constant-voltage power source
44 Wafer heating control means
50 Input panel

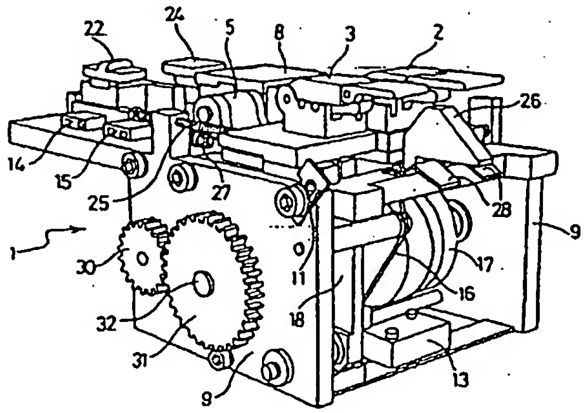


Figure 1

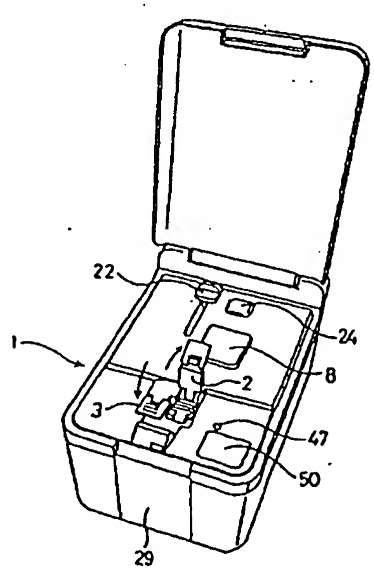


Figure 2

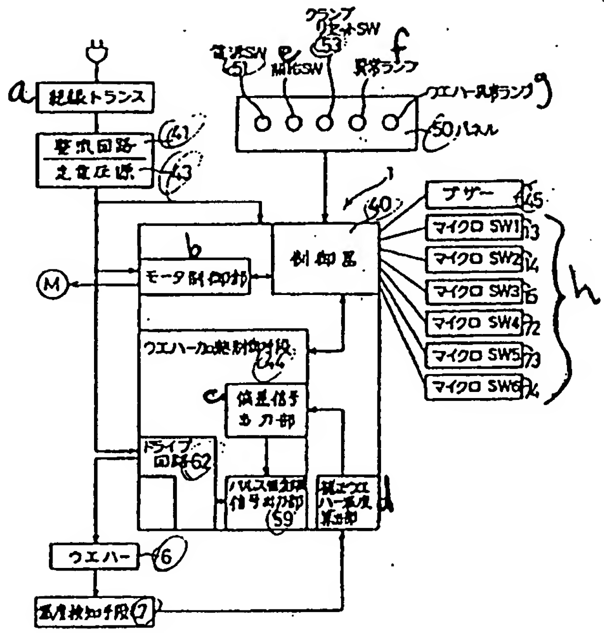


Figure 3

Key:

a	Insulating transformer
b	Motor control unit
c	Error signal output unit
d	Correction wafer temperature calculating unit
e	Start SW
f	Abnormality-indicating lamp
g	Wafer abnormality-indicating lamp
h	Micro SW
6	Wafer
7	Temperature detection means
40	Controller
41	Rectifying circuit
43	Constant-voltage power source
44	Wafer heating control means
45	Buzzer
50	Panel
51	Power source SW
53	Start SW
59	Pulse-width modulation signal output unit
62	Drive circuit

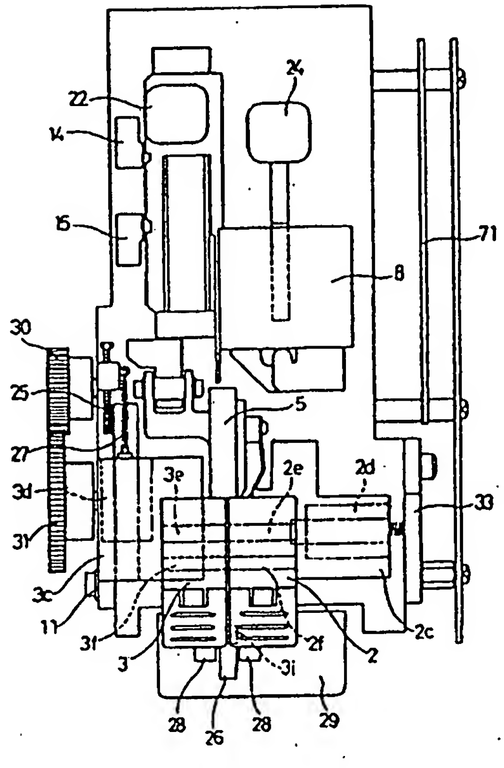


Figure 4

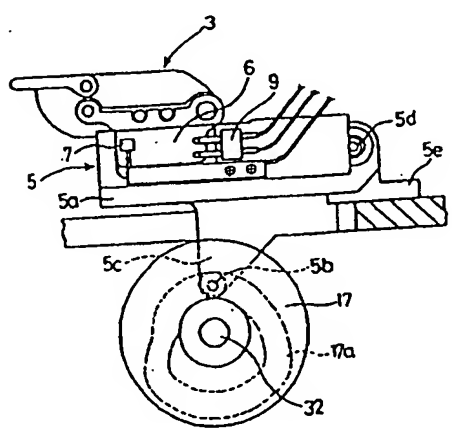


Figure 5

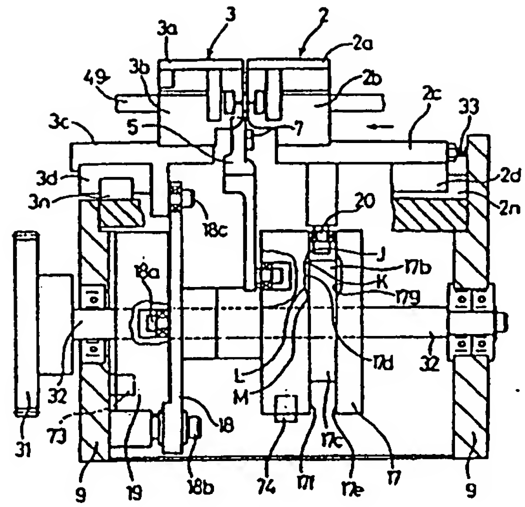


Figure 6

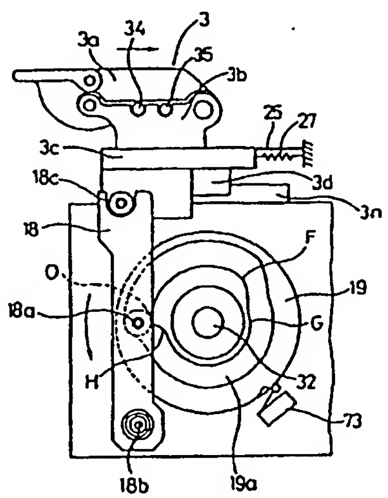


Figure 7

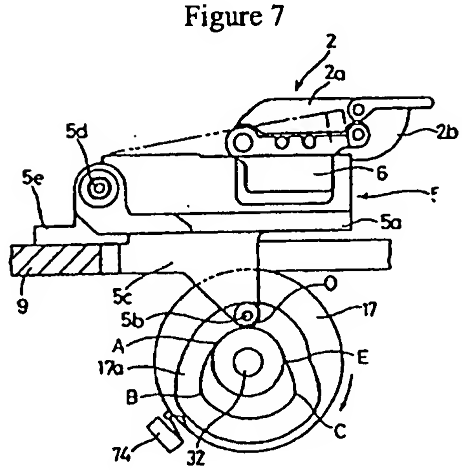


Figure 8

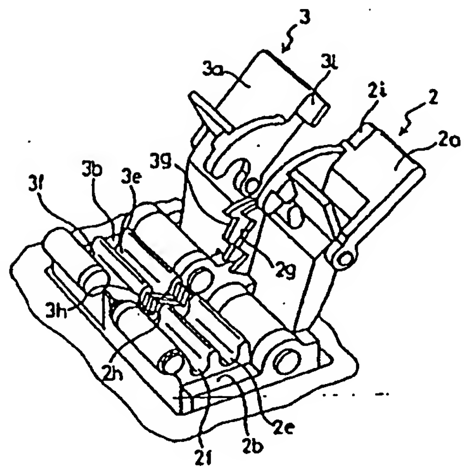


Figure 9

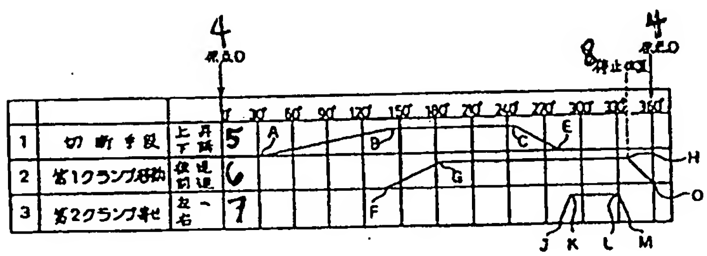


Figure 10

Key:
1 Cutting means
2 Movement of the first clamp
3 Shifting of the second clamp
4 Origin
5 Rise
Descend
6 Backward
Forward
7 To the left
To the right
8 Stop position

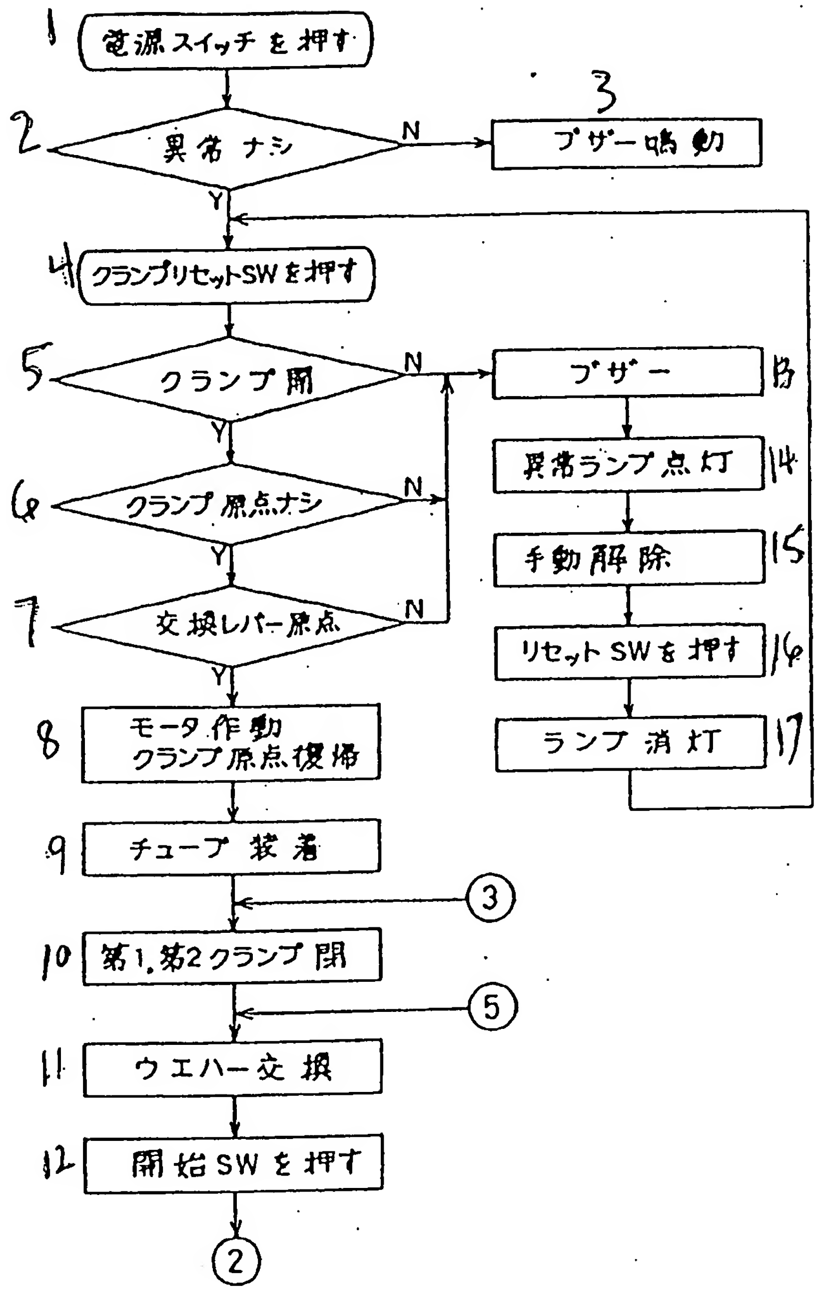


Figure 11

Key:
1 Power source switch is pushed
2 There is no abnormality?
3 Buzzer is turned on
4 Clamp reset SW is pushed
5 Is clamp open?
6 There is no clamp origin?
7 Exchange lever origin?
8 Motor is turned on, and clamp origin is recovered

9 Tubes are installed
10 First and second clamps are closed
11 Wafer is exchanged
12 Start SW is pushed
13 Buzzer
14 Abnormality-indicating lamp is turned on
15 Manual release
16 Reset SW is pushed
17 Lamp is turned off

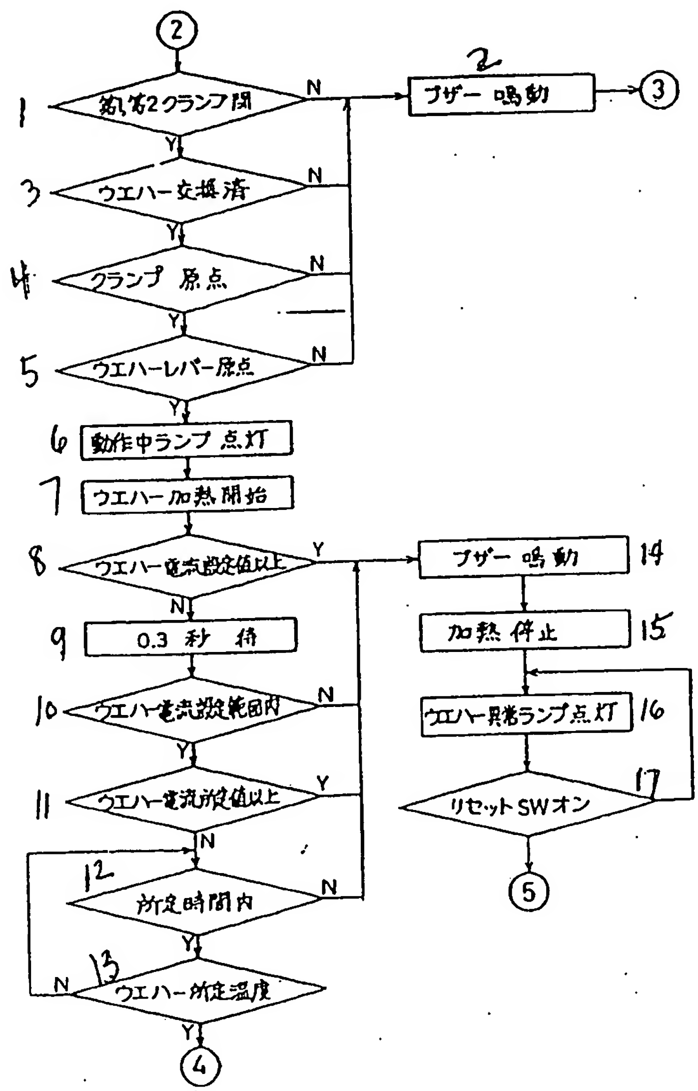


Figure 12

Key:

1	Are the first and second clamps open?
2	Buzzer is turned on
3	End of wafer exchange
4	Clamp origin?
5	Wafer lever origin?
6	Operation-indicating lamp is turned on
7	Start of wafer heating
8	Is the wafer current higher than the preset level?
9	Wait for 0.3 sec
10	Is the wafer current within the preset range?
11	Is the wafer current above the preset level?
12	It the time shorter than the prescribed time?
13	Is the wafer at the prescribed temperature?
14	Buzzer is turned on
15	Heating is stopped
16	Wafer abnormality-indicating lamp is turned on
17	Is the reset SW on?

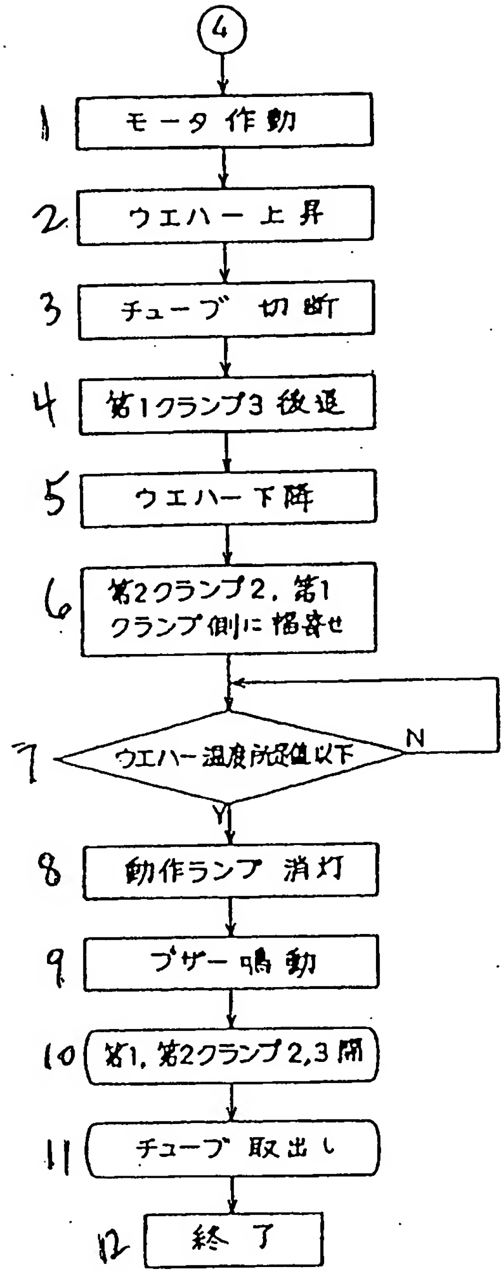


Figure 13

Key:
1 Motor is turned on
2 Wafer is raised
3 Tubes are cut
4 First clamp (3) retreats
5 Wafer descends
6 Second clamp (2) laterally shifts toward the first clamp
7 Is the wafer temperature below the prescribed level?

8 Operation lamp is turned off
9 Buzzer is turned on
10 First and second clamps (2) and (3) are opened
11 Tubes are removed
12 END

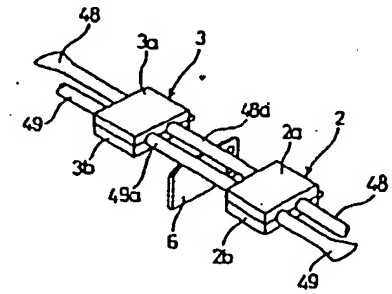


Figure 14

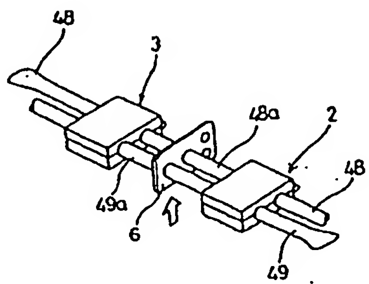


Figure 15

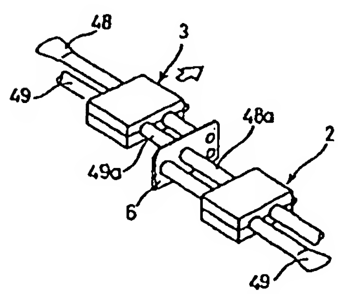


Figure 16

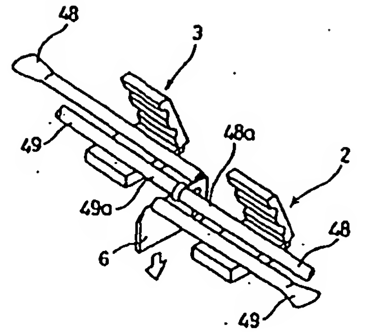


Figure 17

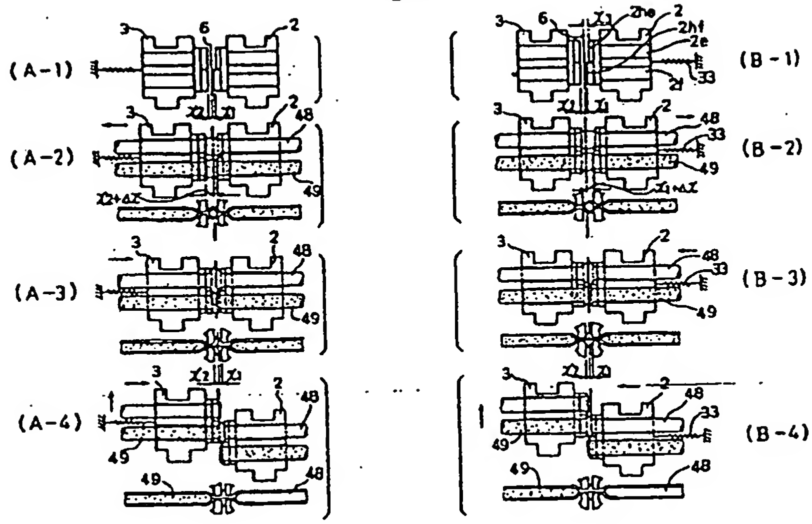


Figure 18

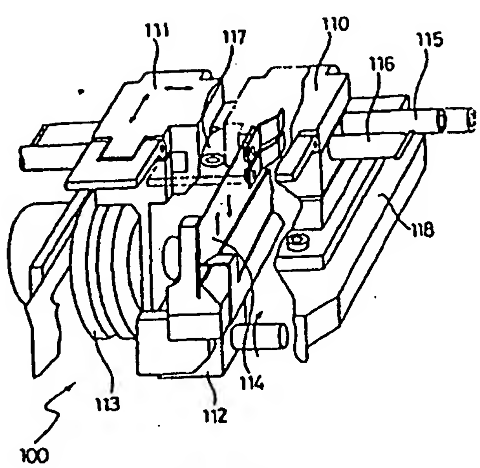


Figure 19